APPENDIX

1. Abstract

Contained within this Appendix is a review of materials investigated as possible sustainable solutions to the material needs of French Polynesia, Material Summary and Element Matrix. . Other information contained within this Appendix pertains to the proposed collection routes, calculation of waste from current copra production and information about outreach, champions and partners. Lastly, the field notes and summary of trip findings are also contained herein.

2. Material Investigation

Palm Oil Fuel Ash in Concrete

If coconut ash could be collected, it should be tested for properties similar to Palm oil fuel ash (POFA). The most important tests are: particle size distribution, loss on ignition (a relative measure of unburnt carbon), x-ray diffraction to identify percentage of amorphous silica. The information below pertaining to POFA would also likely apply to coconut oil ash, which appears to be an unstudied area.

Processing

In its original state, POFA has low pozzolanic reactivity due to its large particle size and porous structure. To increase reactivity of POFA, the ash should be ground to a mean particle size of 10µ, (see Figure 1 and 2). Ball milling provides an adequate grinding method. Sata *et al.* obtained their POFA from a power plant in Thailand.

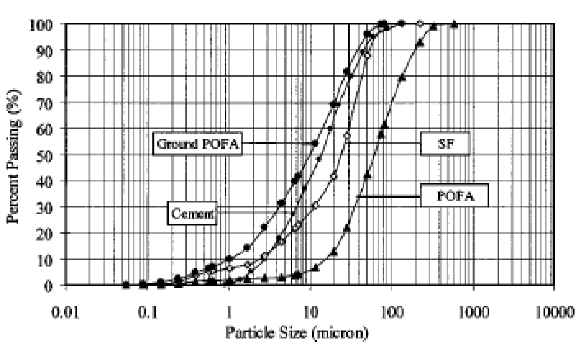

Figure 1: Particle size distribution[1]

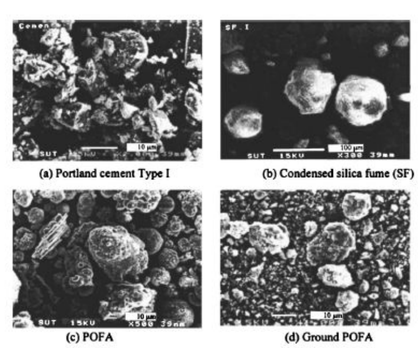

Figure 2: Scanning electron microscope[1]

Mechanical Properties
The significant mechanical changes in concrete containing POFA are increased compressive strength, lower elastic modulus, and reduced peak temperature. Addition of POFA up to 30% by weight of total cementitious materials reveals an increase in compressive strength (see Figure 3). Lower amounts of POFA (10-20%) reveal more significant strength gains.

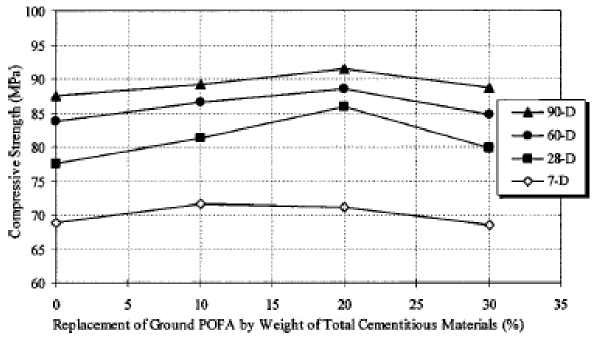

Figure 3: Compressive strength with various amounts of POFA [2]

The modulus of elasticity has been shown to decrease slightly for additions of POFA of 30%. The reasoning behind this lower amount is due to the decreased coarse aggregate content in the POFA mix. Finally, heat evolution can be controlled through the use of POFA. A reduction of 15% in the peak temperature compared to the control sample is observed [1].

Cement Composites Reinforced with Coir Fibers

Processing
The outside of a coconut (cocos nucifera) is composed of a protective shell (12%) and a fibrous husk (35%); the husk is 70% cork-pith material and 30% coir fiber [2]. The fiber is extracted from the pith by a mechanical decortication process. The simplest method uses the fibers after the pith has been removed. However, the fibers can also be used in thin sheets through a non-woven process. These sheets are then used with sandwich technology to create a composite element, also known as coir mesh reinforced mortar (CMRM) (see Figure 4).

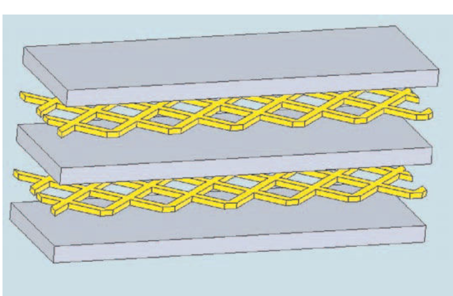

Figure 4: CMRM sandwich technology[2]

Mechanical Properties

Coir fiber both as a mesh or individual fibers has been shown to dramatically increase the performance of composite materials [2, 3]. Stress-strain curves for the differing percentages of fiber mesh are presented in Figures 5 and 6. The control specimen has no toughening effect, whereas the use of the fiber mesh reveals significant toughening, which also correlates to higher energy absorption. The CMRM composites also recorded a 40% increase in flexural stress, 25 times improvement in flexural toughness and a higher toughness index [2]. Multi-layer meshes have been shown to have increased performance compared to single layer performance. A direct comparison of individual fibers versus fiber meshes has not been conducted, but the same positive attributes are found in both system.

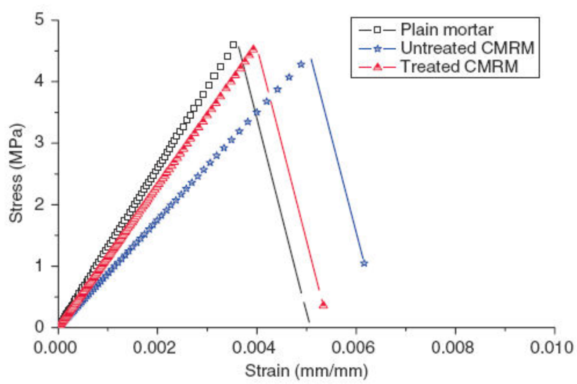

Fig 5. Stress-strain curve of **0.6%** CMRM and control specimen.[2]

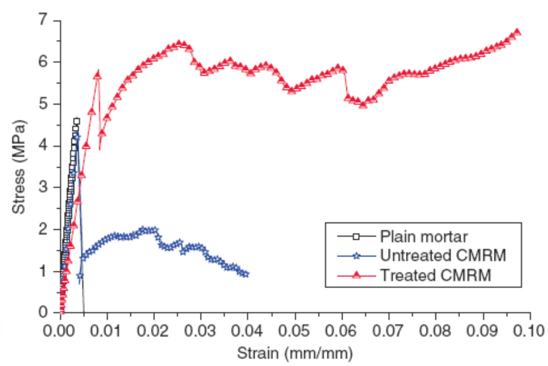

Fig 6. Stress-strain curve of **1.2%** CMRM and control specimen.[2]

Potential challenges of coir fibers are durability and bonding. The alkaline media of cement acts to weaken coir fibers; however, these fibers were found to perform superior to numerous other fibers due to their low water absorption [3]. To improve long term durability, and hence performance, of coir fibers a reduction of the alkalinity of the matrix should be pursued. Finally, concerns over the transition zone between the fiber and cement matrix seek to improve the quality of bond between the two materials. Through the use of wetting agent the fibers are able to better bond to the matrix and hence perform more favorably (see Figure 5 and 6) [2].

Polymeric Panels

Several mix designs were analyzed in the process of evaluating the potential capability of the panel for construction use. Mainly, the polymer blend, the amount of carbon black and magnesium hydroxide were varied to select the optimal mix. Flexural and compression strength tests were conducted on the various mixes for assessment. The maximum, minimum and average ranges of test results were compared with common construction materials currently used for interior paneling. The results are contained within the graph below:

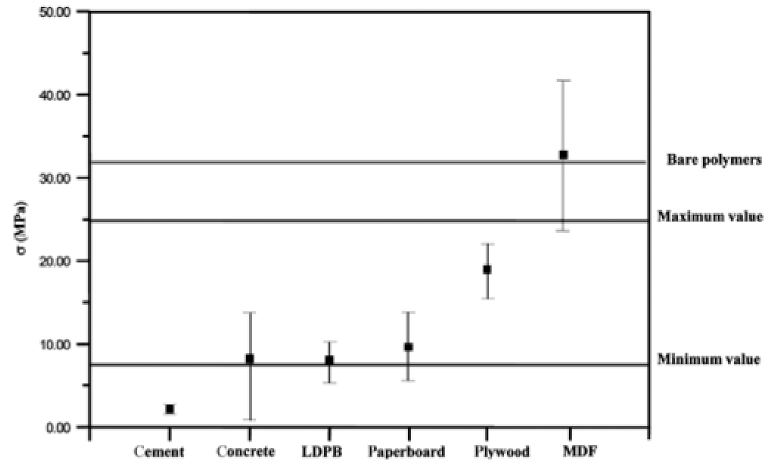

Figure 7 – Limits of Strength as Compared to Common Building Materials [4]

As illustrated by the Figure 7, the strength range is comparable to other commonly used building materials. Also, by testing it was shown that PP + PE blends had the best mechanical properties and also that limiting the additive amounts improved them as well.

Cement Tiles from Plastic Wastes

The cement tiles are comprised of the following components: plastic wastes and natural sand. The sorted plastic wastes were cleaned and shredded to particle sizes less than 2.36 mm.

Performance of the cement tiles was determined to be equal to or better than current interior tiling technologies. The following graphs illustrate the compressive and the flexural strength of various mix designs:

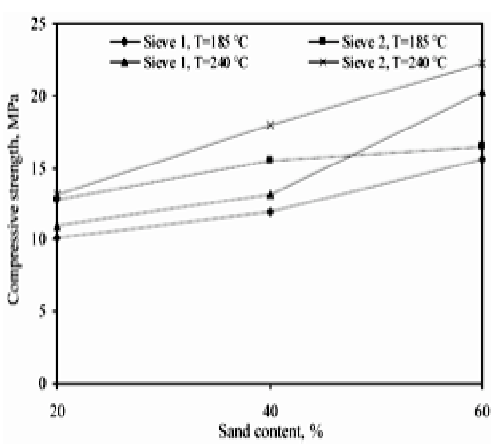

Figure 8 – Compressive Strength vs. Sand Content [5]

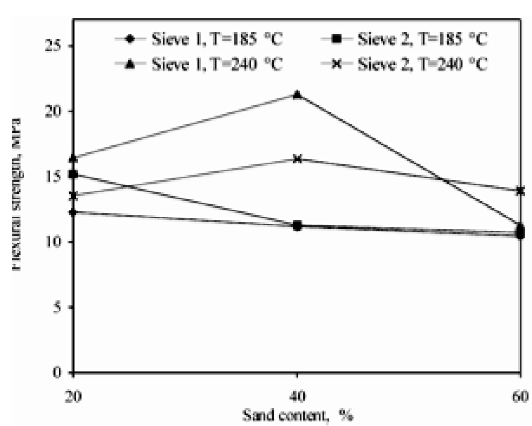

Figure 9 – Flexural Strength vs. Sand Content [5]

As determined by the results of the study the ideal mix is heated around 240°C with a higher sand particle size (2.36 mm) and lower sand content (20-40% by wt). Lastly, for improved fire proofing to standard building code a coating of glue and magnesium hydroxide is painted on to the panel [5].

Three-Dimensional Engineered Fiberboard

The US Forest Products Laboratory (FPL) originally developed three dimensional engineered fiberboard (3DEF) for application to emergency housing. The goal was a lightweight, portable, reusable, recyclable and biodegradable temporary building system. The real feature of this system is its flexibility. It is not sensitive to inks, oils and other contaminates commonly found in recycled paper. It can use fiber from a variety of sources. 3DEF from purely natural fibers (wood waste) was successfully produced with no added binder, however this was found suitable only for interior use. Research has shown that natural and synthetic resin binders can successfully be added. The performance of the panels with resin achieve meet the "Exposure 1" rating for engineered wood composite panels such as plywood and OSB. Again specific study had not yet been done using coconut husk. FPL is currently looking for grant partners to conduct further research; this may be of interest to a UCB ERG project.

3. Element & Material Matrix

The Element Matrix categorizes all the structural and architectural components of the original kit-home. The object of the matrix was to illustrate where overlap between different components could be meet with the same material; thereby, increasing the percentage of sustainable materials in the structure. For each element the necessary geometry, structural, and durability properties are defined. Possible sustainable materials are identified and finally the quantity (m^2) of this element that would be used in a single kit-home is presented. The quantity is useful in illuminating which elements would provide the greatest material savings.

ELEMENT	PROP 1 / geometry & other	PROP 2 / structural	PROP 3 / durability	Notes/Questions	Possible Materials/Products (for descriptions see Material Summaries table)	Quantity (m^2)
EXTERIOR SHEATHING PANEL	Standard sheet sizes (4'x8'x ½" – ¾" equiv.)	1) Moderate out-of-plane stiffness 2) In-plane stiffness (anti-racking), for shear strength. 3) Nail base: crushing resistance.	1) Water resistance 2) Not a mold growth habitat 3) Edges must not delaminate	1) How is this panel finished (paint, stucco, etc)? 2) Aesthetic concerns. Details to work out: 3) Panel to panel connections 4) Connection of panels to studs/post, plates/headers	1) Coir/resin panel 2) Coir/PAcement panel 3) Coir/rec'd plastic panel	70
COUNTER UNDERLAYMENT, PANEL	Standard sheet sizes (less 4'x8' ok). Min. thickness: ½" – ¾" equiv. Thicker req'd if counters cantilever.	1) Moderate in and out-of-plane stiffness 2) Cantilevered counter not recommended; requires stronger thicker panel 3) If panel will be the counter top finished surface see "counter finish material" below.	1) Water resistance 2) Not a mold growth habitat 3) Edges must not delaminate	1) What is the finish material? 2) Could "rough panel" also work as finish? 3) Waterproofing? 4) Non-toxic surface for food prep	1) Coir/resin panel 2) Coir/PAcement panel	5

ELEMENT	PROP 1 / geometry & other	PROP 2 / structural	PROP 3 / durability	Notes/Questions	Possible Materials/Products (for descriptions see Material Summaries table)	Quantity (m^2)
COUNTER FINISH MATERIAL	variable	1) Hardness, resistance to denting and impact 2) Cuttable - for forming to various counter designs 3) Abrasion resistance	1) Washable, scrubbable 2) Non-toxic for food prep 3) Not a mold growth habitat 4) Replaceable	1) What are the food prep habits? 2) Do Tahitians do a lot of chopping? Do they tend to use the counter to chop or are cutting boards the norm? If they cut right on the counter the finish material must accommodate that without degrading or ruining their knives.	1) Recycled glass tile 2) Coir/rec'd. plastic panel 3) Coir/PAcement	5
BATHROOM TILE	Variable, modular	1) Hardness, resistance to denting and impact 2) Cuttable - for forming around plumbing and bathroom elements 3) Abrasion resistance	1) Washable, scrubbable 2) Not a mold growth habitat 3) Replaceable	1) What is the current MTR bathroom finish? 2) What type of material is preferred, why? 3) Aesthetic concerns. 4) Can plastic hold up to scouring?	1) rec'd. plastic panel 2) rec'd. plastic tile 3) rec'd. glass tile	11

ELEMENT	PROP 1 / geometry & other	PROP 2 / structural	PROP 3 / durability	Notes/Questions	Possible Materials/Products (for descriptions see Material Summaries table)	Quantity (m^2)
SUB FLOORING, PANEL	Standard sheet sizes (4'x8'x ½" – ¾" equiv.)	1) Moderate in and out-of-plane stiffness 2) Nail base: nailable with crushing resistance 3) Compatibility with finish material requirements	1) Water resistance 2) Not a mold growth habitat 3) Edges must not delaminate 4) If panel will be the finished floor surface see "finished floor material" below.	Details to work out: 1) Panel to panel connections 2) Connection of panels to floor joists	1) Coir/resin panel	70
FINISHED FLOORING MATERIAL	Variable	1) Tough, repairable. 2) Structural req't depends on whether a soft (e.g. textile) or hard finish is used 3) Easily cut for fitting around walls etc	1) Must be cleanable 2) Different durability for different zones?	1) Aesthetic concerns. 2) What are the cultural preferences re flooring? 3) Acoustics – Hard vs soft surfaces? 4) What are the house keeping habits?	1) Recycled glass tile 2) Coir/resin panel 3) Thin-set PAcement	70
INTERIOR WALL, PANEL	Standard sheet sizes (4'x8'x 3/8" – 5/8" equiv.)	1) Low in and out-of-plane stiffness 2) Easily cut for fitting around doors, electrical outlets etc 3) Soft – must take pins, finish nails for picture hanging etc. (?? Is this desirable??)	1) Can be washed or painted 2) Not a mold growth habitat 3) Repairable	1) How is this panel finished (paint, wall paper, textile, etc)? 2) Aesthetic & acoustic concerns: Hard vs soft surfaces. 3) Traditional/current preferences? Details to work out: 4) Panel to panel connections – taping like dry wall?	1) Recycled paper panel 2) Coir/resin panel 3) Coir/PAcement panel	20

ELEMENT	PROP 1 / geometry & other	PROP 2 / structural	PROP 3 / durability	Notes/Questions	Possible Materials/Products (for descriptions see Material Summaries table)	Quantity (m^2)
CEILING MATERIAL	Standard sheet sizes (4'x8'x 3/8" – 5/8" equiv.)	1) Low in and out-of-plane stiffness 2) Easily cut for fitting around lights, electrical outlets etc 3) Soft – must take pins, finish nails for picture hanging etc. (?? Is this desirable??)	2) Can be washed or painted 3) Not a mold growth habitat 4) Repairable	1) How is this panel finished (paint, wall paper, textile, etc)? 2) Aesthetic & Acoustics concerns: Hard vs soft surfaces. 3) Traditional/current preferences? Details to work out: 4) Panel to panel connections – taping like dry wall?	1) Recycled paper panel 2) Coir/resin panel	70
ROOFING	Standard sheet sizes (4'x8'x ½" – ¾" equiv.) Shape designed to shed water, such as corrugated	1) Moderate out-of-plane stiffness 2) In-plane stiffness (anti-racking), for shear strength. 3) Nail base: crushing resistance.	1) Water proof 2) Not a mold growth habitat 3) Edges must not delaminate	1) Aesthetic concerns. 2) Heat reflection. Details to work out: 3) Panel to panel connections 4) Connection of panels to roof joists 5) Connection of gutters	1) Coir/resin panel (corrugated shape, covered with PAcement 1) Coir/PAcement panel 2) Existing metal w/ PAcement covering	Sides= 56 Ends= 25 Module= 32 Total= 113
DOORS	Standard sheet sizes (less than 4'x8' panel size is adequate) thickness depends on door type, ½" equiv ok for hollow core.	1) Moderate in and out-of-plane stiffness 2) Dimensional stability – must not swell or warp 3) Nail base: crushing resistance.	1) Washable/paintable 2) Not a mold growth habitat 3) Edges must not delaminate 4) repairable	1) How is this panel finished (paint, stucco, etc)? 2) Aesthetic concerns. 3) Compatible with available Door hinging and hardware	1) Coir/resin panel 2) Recycled paper panel 3) Coir/rec'd. plastic panel	25

The Materials Matrix summarizes possible sustainable materials that would be appropriate for use as a building material. The materials listed are the result of an extensive literature review. A brief description is give for each material as well as the positive and negative attributes. The most important criteria, availability in French Polynesia, served as the crucial factor in the selection of our material recommendation.

Materials Summaries – Information to date: May 15, 2007
This table informs and defines materials listed in matrix above

Material/Product	DESCRIPTION	Local Availability
Coir	Agricultural waste product from the palm/coconut/copra industry. Coir is the husk material between the coconut inner shell and outer shell. It contains both fibers and lignin. **POSITIVES:** Waste-product, good tensile element in composite matrix **NEGATIVES:** Waxy surface may require pre-treatment; can imbibe h2o	Possibly abundant
Resin	A binder, herein meaning a natural binder obtained from the lignin portion of the coir. **POSITIVES:** Waste-product, good natural adhesive, (low/zero toxicity?) **NEGATIVES:**	Possibly abundant
PAcement	Palm Ash (PA) is a waste-product from the palm oil industry. It is pozzolanic binder, meaning it can replace significant portions (+/-50%?) of portland cement (PC). PAcement herein means a cement mortar matrix consisting of local sand and maximum workable portions of PA + PC+ water. Other fine aggregates from recycled materials (crushed glass etc) are also possible inclusions. **POSITIVES:** Waste-product. Less permeable more durable mortar. **NEGATIVES:** possibly increased set time at high proportions	Not available

Materials Summaries – Information to date: May 15, 2007 This table informs and defines materials listed in matrix above		
Material/Product	**DESCRIPTION**	**Local Availability**
Coir/resin panel	Panel material made from coir and resin. The coir fiber and lignin is heated and rolled together forming sheet material. We are looking for more information to see if a OSB (or plywood) type panel exists. **POSITIVES:** Known entity - currently being implemented with a pilot plant in the Phillipines. Scale of production seems applicable. Good structural properties for strength (similar too but stronger than MDF) **NEGATIVES:** Like MDF this is a relatively brittle material and cannot be nailed through. This complicates connection detailing. Panels would have to be screwed to supports through pre-drilled holes.	Must establish local manufacturing
Coir/PAcement panel	Panel material made from coir and PAcement. The coir fiber would be incorporated as fibrous reinforcement in a composite panel. **POSITIVES:** Similar to current imported product. Connection detailing may be modeled after current product. **NEGATIVES:** Less information currently found. No known manufacturing to model after.	PACement not available
	More info and products needed for all materials listed below	
Recycled Glass	Local Household and Commercial Waste – sorting and availability unknown. Possible uses range from a crushed material (fine aggregate) to a finished tile product.	Already being used for another project

Materials Summaries – Information to date: May 15, 2007 This table informs and defines materials listed in matrix above		
Material/Product	**DESCRIPTION**	**Local Availability**
Recycled Paper	Local Household and Commercial Waste – sorting and availability unknown. Area of interest is to create interior wall panels (similar to Homasote). This is a soft material with sufficient stiffness for partitions. Possibly issues with sensitivity to humidity (swelling).	Low quantities
Recycled Plastic	Local Household and Commercial Waste – sorting and availability unknown. Recycled plastics (RP) can take many forms. One area of interest is to use RP in a molten state as binder in a coir fiber panel.	Low quantities

4. Proposed Ferry Routes in French Polynesia

Production of copra over 100,000 Kg

Route	Island Group	Island	Quality	Copra in Kg *(Net)*	Price per unit	Value	Copra in Kg *(Net -Waste)*	Copra waste in Kg	Husk in Kg	Distance (km)	Husk/ km
Route 1	IDV Iles de Vent	**MAIAO**	1er qualitˇ	285959	100.00 F	28,595,900 F	282869	3090	501527		
			2¸me qualitˇ	863	55.00 F	47,465 F	863	0	1530		
				286822		28,643,365 F	283732	3090	503057		
	ISV Iles Sous le Vent	**HUAHINE**	1er qualitˇ	217246	100.00 F	21,724,600 F	217038	208	384808		
			2¸me qualitˇ	2698	55.00 F	148,390 F	2694	4	4776		
				219944		21,872,990 F	219732	212	389585		
		RAIATEA	1er qualitˇ	120626	100.00 F	12,062,600 F	120436	190	213533		
			2¸me qualitˇ	18146	55.00 F	998,030 F	18091	55	32075		
				138772		13,060,630 F	138527	245	245608		
		TAHAA	1er qualitˇ	799672	100.00 F	79,967,200 F	772677	26995	1369956		
			2¸me qualitˇ	541	55.00 F	29,755 F	518	23	918		
				800213		79,996,955 F	773195	27018	1370875		
Total									**5,018,250**	**523**	**9,596**
Route 2	Marquises	**FATU HIVA**	1er qualitˇ	103505	100.00 F	10,350,500 F	99437	4068	176302		
			2¸me qualitˇ	20728	65.00 F	1,347,320 F	19800	928	35105		
				124233		11,697,820 F	119237	4996	211407		
		HIVA OA	1er qualitˇ	426485	100.00 F	42,648,500 F	407811	18674	723049		
			2¸me qualitˇ	36695	65.00 F	2,385,175 F	35110	1585	62250		
				463180		45,033,675 F	442921	20259	785299		
		NUKU HIVA	1er qualitˇ	385243	100.00 F	38,524,300 F	373626	11617	662439		
			2¸me qualitˇ	12625	65.00 F	820,625 F	11968	657	21219		
				397868		39,344,925 F	385594	12274	683658		
		TAHUATA	1er qualitˇ	208986	100.00 F	20,898,600 F	197440	11546	350061		
			2¸me qualitˇ	2019	65.00 F	131,235 F	1892	127	3355		
				211005		21,029,835 F	199332	11673	353416		
		UA HUKA	1er qualitˇ	452174	100.00 F	45,217,400 F	429186	22988	760947		
			2¸me qualitˇ	14741	65.00 F	958,165 F	13699	1042	24288		
				466915		46,175,565 F	442885	24030	785235		
		UA POU	1er qualitˇ	156248	100.00 F	15,624,800 F	148338	7910	263003		
			2¸me qualitˇ	4317	65.00 F	280,605 F	4214	103	7471		
				160565		15,905,405 F	152552	8013	270475		
Total									**6,178,979**	**3,258**	**1,896**
Route 3	Tuamotu Centre	**AMANU**	1er qualitˇ	193,304	100.00 F	19,330,400 F	175,531	17,773	311216		
			2¸me qualitˇ	783	61.21 F	47,925 F	727	56	1289		
				194,087		19,378,325 F	176,258	17,829	312505		
		ANAA	1er qualitˇ	228,214	100.00 F	22,821,400 F	217,881	10,333	386303		
			2¸me qualitˇ	9,466	55.00 F	520,630 F	9,018	448	15989		
				237,680		23,342,030 F	226,899	10,781	402292		
		FAAITE	1er qualitˇ	110,512	100.00 F	11,051,200 F	105,898	4,614	187757		
			2¸me qualitˇ	1,785	55.00 F	98,175 F	1,714	71	3039		
				112,297		11,149,375 F	107,612	4,685	190796		
		HAO	1er qualitˇ	108,814	100.00 F	10,881,400 F	102,373	6,441	181507		
			2¸me qualitˇ	1,327	58.53 F	77,665 F	1,266	61	2245		
				110,141		10,959,065 F	103,639	6,502	183752		
		MAKEMO	1er qualitˇ	188,638	100.00 F	18,863,800 F	176,217	12,421	312433		
			2¸me qualitˇ	4,547	56.76 F	258,095 F	4,292	255	7610		
				193,185		19,121,895 F	180,509	12,676	320042		
Total									**2,818,776**	**2,092**	**1,348**
Route 4	Tuamotu Est	**HERETUE**	1er qualitˇ	146,624	100.00 F	14,662,400 F	142,906	3,718	253372		
			2¸me qualitˇ	7,270	55.00 F	399,850 F	7,130	140	12641		
				153,894		15,062,250 F	150,036	3,858	266014		
		NUKUTAVAKE	1er qualitˇ	126,051	100.00 F	12,605,100 F	121,447	4,604	215326		
			2¸me qualitˇ	4,018	55.00 F	220,990 F	3,877	141	6874		
				130,069		12,826,090 F	125,324	4,745	222199		
		REAO	1er qualitˇ	289,619	100.00 F	28,961,900 F	272,899	16,720	483850		
			2¸me qualitˇ	516	55.00 F	28,380 F	482	34	855		
				290,135		28,990,280 F	273,381	16,754	484705		
		TATAKOTO	1er qualitˇ	231,123	100.00 F	23,112,300 F	218,463	12,660	387335		
			2¸me qualitˇ	3,691	55.00 F	203,005 F	3,446	245	6110		
				234,814		23,315,305 F	221,909	12,905	393445		
		TEMATANGI	1er qualitˇ	191,166	100.00 F	19,116,600 F	188,198	2,968	333675		
			2¸me qualitˇ	16,242	55.00 F	893,310 F	15,971	271	28317		
				207,408		20,009,910 F	204,169	3,239	361992		
		TUREIA	1er qualitˇ	214,601	100.00 F	21,460,100 F	194,387	20,214	344648		
			2¸me qualitˇ	3,525	55.00 F	193,875 F	3,222	303	5713		
				218,126		21,653,975 F	197,609	20,517	350361		
		VANAVANA	1er qualitˇ	107,700	100.00 F	10,770,000 F	102,091	5,609	181007		
			2¸me qualitˇ	6,020	55.00 F	331,100 F	5,655	365	10026		
				113,720		11,101,100 F	107,746	5,974	191034		
Total									**4,539,497**	**3,379**	**1,343**
Route 5	Tuamotu Ouest	**FAKARAVA**	1er qualitˇ	109,067	100.00 F	10,906,700 F	103,025	6,042	182663		
			2¸me qualitˇ	2,031	55.00 F	111,705 F	1,884	147	3340		
				111,098		11,018,405 F	104,909	6,189	186004		
		KAUEHI	1er qualitˇ	165,728	100.00 F	16,572,800 F	151,997	13,731	269491		
			2¸me qualitˇ	441	55.00 F	24,255 F	397	44	704		
				166,169		16,597,055 F	152,394	13,775	270195		
		KAUKURA	1er qualitˇ	345,639	100.00 F	34,563,900 F	320,109	25,530	567553		
			2¸me qualitˇ	3,578	57.60 F	206,105 F	3,410	168	6046		
				349,217		34,770,005 F	323,519	25,698	573599		
		MATAIVA	1er qualitˇ	258,040	100.00 F	25,804,000 F	241,614	16,426	428382		
			2¸me qualitˇ	1,316	55.00 F	72,380 F	1,212	104	2149		
				259,356		25,876,380 F	242,826	16,530	430530		
		NIAU	1er qualitˇ	194,937	100.00 F	19,493,700 F	188,354	6,583	333952		
			2¸me qualitˇ	335	67.22 F	22,520 F	325	10	576		
				195,272		19,516,220 F	188,679	6,593	334528		
		RANGIROA	1er qualitˇ	405,904	100.00 F	40,590,400 F	361,755	44,149	641392		
			2¸me qualitˇ	639	69.08 F	44,145 F	581	58	1030		
				406,543		40,634,545 F	362,336	44,207	642422		
		TAKAPOTO	1er qualitˇ	322,163	100.00 F	32,216,300 F	309,702	12,461	549102		
			2¸me qualitˇ	9,492	55.00 F	522,060 F	9,138	354	16202		
				331,655		32,738,360 F	318,840	12,815	565303		
		TAKAROA	1er qualitˇ	147,283	100.00 F	14,728,300 F	134,114	13,169	237784		
			2¸me qualitˇ	535	55.00 F	29,425 F	520	15	922		
				147,818		14,757,725 F	134,634	13,184	238706		
		TIKEHAU	1er qualitˇ	155,453	100.00 F	15,545,300 F	136,880	18,573	242688		
			2¸me qualitˇ	1,906	57.43 F	109,465 F	1,707	199	3027		
				157,359		15,654,765 F	138,587	18,772	245715		
Total									**6,974,003**	**1,529**	**4,562**
Rouet 6	Tuamotu Nord-Est	**FAKAHINA**	1er qualitˇ	271,936	99.23 F	26,985,430 F	255,833	16,103	453592		
			2¸me qualitˇ	712	55.00 F	39,160 F	675	37	1197		
				272,648		27,024,590 F	256,508	16,140	454789		
		PUKA PUKA	1er qualitˇ	283,742	100.00 F	28,374,200 F	263,979	19,763	468035		
			2¸me qualitˇ	11,272	55.00 F	619,960 F	10,512	760	18638		
				295,014		28,994,160 F	274,491	20,523	486673		
		NAPUKA	1er qualitˇ	123,991	100.00 F	12,399,100 F	116,122	7,869	205884		
			2¸me qualitˇ	9,526	55.00 F	523,930 F	8,822	704	15641		
				133,517		12,923,030 F	124,944	8,573	221526		
Total									**2,325,974**	**2,574**	**904**

5. Cost Comparison

<u>Pertinent Data for Cost Analysis:</u>
Diesel = $1.10/L (wholesale) [6]
45 MJ/kg x 0.2778 KWh/MJ x 0.885 kg/L = 11.06 KWh/L
$1.10/L x (1/11.06 KWh/L) = $0.10/KWh cost of diesel

Electricity = $0.40/KWh (wholesale cost of power, previous groups report)

Annual power draw for coir board production of 15,000 m^3/yr = 3,078MWh/yr

15,000 m^3 of board: 1 m^3 is equivalent to 53 panels (4'x8'x1/4") and a surface area of 158 m^2. Total production = 2.4 Million m^2 of ¼" thick panels, or 1.2 Million m^2 of 1/2" thick panels.

<u>Market/demand</u>
The kit-home uses approximately 460 m^2 of material. At 1.2 million production level could supply 2,600 kit-homes. So there is excess capacity (about 75%) for selling on the commercial market for the construction of developments, resorts, private homes and commercial and institutional building.

<u>Cost of current material</u>
Both MDF and construction grade plywood are currently priced around $250/$m^3$ [7], the wholesale export market price, shipping not included. Assuming a 20% premium for shipping and handling to and around French Polynesia, a price of $300/$m^3$ is used. Use this value as a baseline.

<u>Estimate of operating cost/yr</u>
1. Overhead costs are assumed to be 10% of the total revenue (standard markup value). Thereby, if the total revenue is based on a 25% return on initial investment ($500,000) then the total overhead is $50,000 per year.

2. Assume 8 full time employees at $20,000/yr.=$160,000/yr (assume state covers health care and other benefits)

3. Energy (using data from above)
    Grid connected = 3078Mwh/yr x $0.40/KWh = $1.23milion/yr
    Diesel = 3078Mwh/yr x $0.10/KWh = $307,800/yr
    Coconut oil = similar cost as diesel

Note: diesel and coconut oil require large capital investment to purchase diesel generators.

6. Outreach, Champions, and Partners

As previously mentioned, the Gump Research Station is a unique resource to the University of California at Berkeley. The staff at the Gump Station coordinate research, course work, seminars, conferences, accommodations, and other essential roles in running a research center. For our project the Gump Station will continue to be a major source of assistance in regards to local contacts, regional knowledge, meeting coordination, and accommodations of visiting researchers. It is anticipated that while the Gump Station will and has been an active participant in this ongoing project a champion outside of the Station would also be needed.

Aside from the Gump Station, various government officials and other important players in French Polynesia have been contacted regarding further assistance with the implementation stages. The individuals are Tariaina Pinson (Service de Development Rural, Agriculture), Stephane Defranoux (Service de Development Rural, Forestry), Charles Egretaud (Pae Tae Pae Uta- Environmental Consultant), Matahiarii Tutuavae (Charge de Mission Environnement), Raimana Martin (Environmental Consultant), Moeha Teriitahi (Minstre du Development des Archipels et Energies Renouvelables), Frederiz Teriiatetoofa (Technical Advisor to Minstre du Development des Archipels et Energies Renouvelables).

Finally, as the scope of the project has expanded to address issues of climate change and sustainable livelihoods, it seems appropriate to contact international groups also focused on these goals. French Polynesia's status as a French Territory puts it at a disadvantage for international funding, which focuses mainly on developing countries. Specific organizations that might be of interest include the World Bank, United Nations Framework Convention on Climate Change, Global Environmental Facility, United Nations Development Programme, and United Nations Environment Programme.

The World Bank aims to provide technical and financial assistance to developing countries as a means to achieve a poverty free world. Unfortunately, of the nine Pacific Island member states receiving aid from the World Bank, French Polynesia is not included. The United Nations Framework Convention on Climate Changes (UNFCC) is an international treaty that addresses global climate change. The financial mechanism for the UNFCCC is the Global Environmental Facility (GEF). The GEF offers financial assistance to developing countries for projects that protect the global environment. The GEF provides funding to developing countries, which would seem to eliminate French Polynesia as a potential beneficiary. However, projects focusing on the overall Pacific island region have been funded with this grant before.[8,9] Finally, the United Nations Development Programme UNDP focuses on developing countries similar to the GEF. French Polynesia is not considered a developing country by the UNDP so this program is not appropriate for our project.

The United Nations Environment Programme (UNEP) is the environmental arm of the United Nations. Of the numerous awards and grants offered by the UNEP, The Seed Initiative appears the most promising for sustainable materials funding in the project.[10]

The award supports innovative and entrepreneurial partnerships that relate to the integration of environmental, social, and economic sustainability. At least three partner organizations from varied stakeholder groups are required. Entrepreneurial activities should be driven by local actors. Copies of the drafted letters are contained in the next two pages.

title and name
address
address
address

FPSM Project
c/o H.Meryman
203 Virginia Ave
San Francisco, CA
94110 USA

Dear XXX, May 15, 2007

A group of graduate engineering students at UC Berkeley has been researching potential technologies that could provide island communities a means to locally produce modern and sustainable construction materials. Two of us visited Tahiti and Moorea in French Polynesia in March of 2007 to explore the viability of the most promising ideas. We met with ten Government and other professionals. This was instrumental in defining a plan for sustainable materials/sustainable-livelihoods in French Polynesia. The most promising technologies use coconut waste (coir) as source material for binder-less boards. The majority of coconut production is concentrated on the island of Tahaa and on the islands of the Tuamotus Archipelagos. We suggest that new manufacturing of sustainable building materials may help develop more sustainable livelihoods by using the coconut waste sourced from these areas. Below is brief description of a possible scenario:

Coir board: The fibers and resin from the coconut husk, is pressed into a binder-less panel. This could be used for internal and exterior walls to replace imported composite wood panels. A small-scale manufacturing plan involves the following:

a. Build a small coir board manufacturing plant on Tahaa or an island in the Tuamotus. The plant provides at least five jobs and uses simple proven technology, such as presses that could be purchased second hand on the global market.
b. Husks could be dried and ground on the source island, giving the islanders/farmer an opportunity to sell a value-added product.
c. The inter-island ferry that collects copra (the white meat that eventually goes to the Capitol for coconut oil production) could also pick up milled or raw coconut husk. The husks would be dropped off at the island where the plant is located.
d. The capital investment required for a small-scale manufacturing is estimated at less than $2M (US). This would produce approximately 1.9 M ft^2 of high-density panels at a cost of $5/panel. Current retail price of similar panels in the US is around $13.
e. The volume of material produced could be earmarked for the construction of the current French Polynesian low and middle-income kit houses. The French Polynesian Government and UC Berkeley have a standing contract to test climate data on a kit house at the UC Berkeley research station in Moorea; it may be possible to amend this contract to include material performance testing.

This product was developed by Agrotechnology with funding and supervision from UN agencies (Common Fund for Commodities, Food and Agriculture Organization). There will be a conference to establish the technology transfer protocol in June; the UN intends to make the technology available to all coconut producing countries.

Advantages of this scheme:
1. Local income for persons in the Tuamotus and/or Tahaa.
2. Reduced material needs from outside French Polynesia.
3. Reduced global warming impact of all construction activities using these products.

We respectfully ask that you consider this plan and how you might help make some version of it happen. We are looking for contacts with individuals, organizations or government entities that may be interested in championing this plan. We are interested to know your opinion of this proposal, all feedback will be appreciated. For additional information, please visit: http://eetd.lbl.gov/staff/gadgil/teaching.html after June 15th to view our full report.

Thank you very much.

Sincerely,

John Anderson, Helena Meryman, Kimberly Porsche

FPSM Project
c/o H.Meryman
203 Virginia Ave
San Francisco, CA
94110 USA

title and name FP Professional
FP address if known
address
address

May 15, 2007

Dear title and name FP Profession,

Thank you again for taking the time to meet with us during our time in French Polynesia.

As you may already be aware, a group of graduate engineering students at UC Berkeley has been researching potential technologies that could provide island communities a means to locally produce less expensive and modern sustainable construction materials. Two of us visited French Polynesia in March of 2007 to explore the viability of the most promising ideas. Meetings with Government and other professionals in Tahiti and Moorea, has helped us refine the focus of our work on locally made modern building materials in French Polynesia. The most promising technologies use coconut waste (coir) as source material for binder-less boards; these can replace the engineered wood panels imported from the USA. The majority of coconut production is concentrated on the island of Tahaa and on the islands of the Tuamotus Archipelagos. New manufacturing of sustainable, modern building materials will create sustainable livelihoods by using the coconut waste sourced from these areas. Below is brief description of a possible scenario:

<u>Coir board</u>: The fibers and resin from the coconut husk, is pressed into a binder-less panel. This could be used for internal and exterior walls to replace imported composite wood panels. A small-scale manufacturing plan involves the following:

a. Build a small coir board manufacturing plant on Tahaa or an island in the Tuamotus. The plant uses simple proven technology and provides at least five local jobs at the plant. Additional employment will be created from the multiplier effect (e.g. for transport, warehousing, marketing etc.)
b. Husks could be dried and ground on the source island, giving the islanders/farmer an opportunity to sell a value-added product.
c. The inter-island ferry that currently collects copra could also collect milled or raw coconut husk. The husks would be dropped off at the island where the plant is located.

<u>Advantages of this scheme:</u>
1. Local income for persons in the Tuamotus and/or Tahaa; potential to reduce copra subsidy.
2. Reduced material needs from outside French Polynesia.
3. Reduced global warming impact of all construction activities using these products.

We respectfully ask that you consider this plan and how you might help make some version of it happen. We are looking for contacts with individuals, organizations or government entities that may be interested in championing this plan. We are interested to know your opinion of this proposal, all feedback will be appreciated. For additional information, please visit: http://eetd.lbl.gov/staff/gadgil/teaching.html after June 15th to view our full report.

Thank you very much.

Sincerely,

John Anderson, Helena Meryman, Kimberly Porsche

7. Trip Summary - March 31st, 2007

Possible local materials

-*Cement-ash from coconut byproducts*

Husk and other coconut byproducts are not being collected on a massive scale. The waste is being burned by individuals making the collection of large quantities of ash difficult. A system of collection of byproducts accompanying the pickup of cophra during boat trips around French Polynesia.

-*Coir board from coconut byproducts*

The idea was well received, but again the distributed sources of coconut byproducts remain the challenge to overcome. Local production of the panels on an outer island would be supportive of the government's goal of preventing a total inflow of people into Tahiti for work. However, the number of people employed by such a system would be minimal.

-*Local woods (Caribbean Pine, Bamboo, Coconut wood)*

Local wood is being sought for both construction and local artisans; hence lessening the need for foreign imports. Caribbean Pine is the main option for the construction industry. Bamboo is not seen as desirable by the majority of residents, for they would like 'modern' housing. Also, local production remains expensive and any construction with bamboo is with material imported from Bali. Coconut wood is being explored by outer island communities. They view it as a means of self employment and economic livelihood. However, the wood bureau doesn't share these sentiments.

-*Local cement (phosphates)*

Rumors of local cement and phosphate based cement on an island have yet to be confirmed. Such a source might be interesting for a short term solution.

-*Agricultural fiberous waste (pig manure)*

This option did not reveal itself to be viable due to the small number of farms and the lack of incentive for the farmer. One might pursue this option further, but it might prove challenging.

Future steps:

1) Find a local champion of this project.

While all parties interviewed are interested in the idea of local materials, none were willing to take this on as their own project.

2) From suggestion of the most viable option (to be determined in the coming weeks) undertake manufacturing test

3) Determine local performance of most viable option in a test setup scenario

4) Build network for ongoing project.

8. Field Notes

Sunday, March 25th, 2007

Ruta Konvalinka
Atelier Ra Moorea
Tel. (689) 56 31 72

Conversed with local artisan, Ruta Konvalinka, a local artisan in Pihaena, Moorea. Originally from southern California she has a shop, Atelier Ra Moorea, which sells various crafts made from locally grown bamboo. Our initial interest was to determine if local bamboo would be a viable material for construction. She quickly dismissed this idea stating that locals want to live in structures made from modern materials. The curing of the bamboo through smoking the leaves was an example of a traditional method that she saw as regressive. She posed the question, why would people want to live in such a manner, devote so much time to all these time consuming tasks, when modern methods proved more favorable from a time and money perspective. The lack of desire to treat bamboo traditionally also revealed the desire for modern materials in home dwellings. Such traditional materials are not seen as attractive.

With regards to materials that are appropriate for this climate, the biggest concern was durability -- the resistance to fungi and insects. Ruta Konvalinka's house was made from wood 30 years ago and is constantly under threat of rot due to the moist and humid climate.

In Ruta Konvalinka's opinion the local people mostly want cement based building materials such as blocks, concrete masonry units (CMU). This is because this material is more economical and safer in cyclones (however safety is not verified and she added that she does not know how big a concern this is). She personally favors "fiber cement" for durability reasons and because it provides a house less damp than CMU constructions. With regard to the MTRs (now apparently known as OPHs) they are well regarded as superior construction and "they'll make them out of whatever you want" Asked if they were at somepoint made out of CMUs, she reported "no."

An interesting design suggestion by Ruta Konvalinkawas that houses should no be made from double wall construction because the space between the interior and exterior panels just gets infested with bugs and other disturbing things..

According to Ruta Konvalinka, none of the coconut palm on the island of Moorea is commercial, except to the extent that whole coconut fruits (sans husk) are sold from here on Tahiti because they cost 200PF each there. People use the coconuts here for cooking etc, the husk is burned by individuals as the smoke makes a good mosquito repellent. The coir is also used in gardens as mulch. It is used as a growth medium for vanilla, which is in the orchid family and grows in air not soil.

Historically there were many coconut palm plantations (actually I don't know if plantation is the right term, as they may have been natural groves) and with the high cost of land here the coconut farming has been displaced by residential plots. The area around the Gump Station (referred to locally as 'Berkeley') appears to have been all palm plantations. She claimed that her small house, which has a moderate size yard and a shop where she sells crafts, is worth 30 million polynesian francs (~$300,000). Most of commercial copra production will be found on the atolls. We should investigate if the other society islands are producing any significant amounts as this might be close enough to justify transporting the materials.

The cash crop on Moorea is pineapple. This is mainly turned into fruit juice. Tomorrow we plan to try to get a tour of the fruit juice factory, its right across the road. We will also drive to the agriculture college. [3/26 note we will hopefully do these on Thursday]

She mentioned that the Agricultural College would be a good resource. It is located west of the French Biology Station (named Criobe). Criobe sounds like the French equivalent of the Gump Station, but is governed by the organization that deals with all graduates schools in France (EPAG).

Other items from today:
I walked to the supermarket at the base of Cook's Bay. Hours (Sun 5:30-8am- really!, M-F 8-5pm)
We took a walking tour of the area; however, Moorea is very big and we only saw a small portion of the island. Along the walk we took pictures of existing homes, and a few new homes that are being built. Ruta expressed the displeasure of the neighborhood with these projects.

Otherwise it rained a lot this morning. It is Fall here and turning into Winter in the next few months.

It rained a lot this morning, but was nice (i.e. did not downpour) in the afternoon or evening. After dinner with Pierre, a French exchange student, we fought off hundreds of fire ants that had decided to move into the house.

Monday, March 26th, 2007
Awoke early this morning 6am. Researched and re-read the papers on post-consumer plastic recycling.

We meet with Neil Davies, executive director of the Gump Station, and Frank Murphy, general manager of the Gump Station. We explained our project and what we were planning to do during our time in FP. Neil said he would accompany us to Papeete on Tuesday morning, and would set up a few other appointments for us.

We then meet with Val, long time assistant at the Gump Station. She set up a tentative appointment with someone from the Agricultural college on Moorea. She also tried to contact someone from the local Juice Factory to see if we could have a tour of the manufacturing capacities. There are tours for the general public that we could do just on a walk-in basis, but she knows someone that would give a more in depth tour regarding our specific questions and not focus so much on tourist information. However, no one answered the phone.

Then she arranged for us to meet the government official, Romeo, whom is responsible for overseeing MTR, now referred to as OPH (Office of Polynesian Housing), construction on the island of Moorea. He agreed to meet with us and show us the two types of OPH houses that are built: one being wood, the other cement. The location of the OPHs under construction are indicated with a small (2'x 4') sign that reads "FARE OPH;" fare being the Tahitian word for house. They are referred to as OPH maison in French.

The concrete OPH was still under construction. The concrete versions take 2.5 moths to construct which is longer than the wooden OPHs. The decision to have a wood or concrete OPH is determined by the end user. Similar decisions such as whether to have solar water heating or gas is their decision as well. Solar is expensive, and due to the hot temperature warm water showers aren't taken. Here at the Gump dorm the water is luke warm. The future residents can also decide on a color for the house and roof; as well as how many bedrooms (2, 3, or 4) the OPH will have. The wood OPH are cheaper than the concrete; however, the concrete last longer. A wood 4 bedroom OPH costs the same as a 2 bedroom concrete OPH. A 2 bedroom OPH was estimated at **4-6 million CFP** (French Polynesian francs). For the same price a 4 bedroom wood frame could be had. The actual amount paid varies depending on the financial status of the end user. Initially a 100,000 CFP is paid. If the end user meets the minimum requirements this might be all they pay, whereas end users with more income would be required to make additional payments after moving in. The subsides are provided by the French government, and possibly also the French Polynesian government.

As for the concrete OPH it consists of cmu (concrete masonry unit) blocks and precast concrete planks that are made locally in Tahiti. The blocks are 9.5"x19.5" x 6" for exterior and 4" for interior walls respectively. Reinforcing steel in placed within the open cavities of the cmu @ 50cm o/c and then filled in with on-site mixed concrete. The plank is about 4'x12' x 4" (dims unsure). The plank is topped with 3" of concrete and welded wire mesh reinforcement. All the onsite concrete is mixed in a small rotary mixer onsite (as opposed to a ready-mix truck – this apparently is not affordable on Moorea) with local aggregate that comes from Moorea! The aggregate is purchased based on the seizing size desired similar to the US.

Both OPHs site atop concrete/cmu piers that elevate the flooring about 1.5' feet off the ground. In the concrete OPH the flooring slab consists of a precast slab from Moorea, which is toped with a slab poured on site. Exterior and interior walls are formed with cmu; again the interior being the small ones. The edge beams around the perimeter of the building are also reported precast in Tahiti. They are 14" deep and 9" wide and upto 12' long. The only beams cast on site are the upper beams that are above the top row of cmu, serving as window and door headers as well as a top plate. Atop this would sit the roof; it was not that far along in construction so this point is not for sure. The roof materials were there on site, and consist of prefab light weight steel trusses and light weight corrugated decking.

The wood OPH was located at a different site, which we went to next. Again Val came with us, she was driving, and acted as the interrupter. The wood OPH used locally (in FP) grown Caribbean pine for the deck on the outside of the OPH. Romeo explained that this was a hard wood, difficult to work with, and expensive. Three small cuts that ran parallel to the long direction had to be made to prevent cracking (?) over the long run. The use of the Caribbean pine was due pleasing aesthitics. The ceiling height inside is 8' on the dot. The roof is insulated with what looks like fiberglass batts with aluminum radiante paper coating. Before construction the ground was treated chemically fo termites and other pests. According to Romeo (via Val) the treatment is proprietary and implemented by certified professionals. The owner is informed of the system when they move in and instructed on a maintenance plan. Apparently, if properly followed this treatment is effective indefineitly o up to 30 years. If only the initial treatment takes place the termites could return after two years. ** This brings up an interesting idea for design approach: pursue design details with mechanical barriers to termites so that reapplications are not needed and pesticides are not involved.** A surprise was that the fiber cement panel is being used inside exclusively. It is used for interior walls (thin) and or subflooring (thick). The ceiling is PVC. The exterior of the walls is OSB with a press treatment o make it look like wood siding. This is interesting b/c OSB does not have a good reputation for durability in the USA. Other ideas: test coir panel versus OSB or durability with we/dry cycling. Question: Can coir boards incorporate or be treated with borates? What is their food value from a pest perspective?

Tuesday, March 27th, 2007

Morning rain, we woke at 5:30 am to meet Neil and catch a ride to the ferry. We three ferried to Tahiti with the commuters on the 6:50am 25min ride to Papeete. We got Neils run down on the situation re the MTRs. Berkeley has received the kit house but cannot pay the supplier because the FP government has not yet paid UCB. The MTR3 kit house was to be erected on site for climate modeling as part of the UCB/M.Fava contract with the FP gov to produce a bio-climatic house design.

Frederix Teiiatetoofa
Conseiller technique
Minister Du developpement des archipels
(689) 54 89 39
frederic.teriiatetoofa@archipels.min.gov.pf

Heifara Teamotuaitau
Charge de communication
Mobile: (689) 73 16 29
Office: (689) 54 89 39

Heifara.teamotuaitau@arhipels.min.gov.pf

After a quick coffee with Neil, we went to our meeting with the Conseiller Technique at the ministry of the development of the archipels, charge des transports interinsulaires et des energies renouvelables, M. Frederix Teriiatetoofa. Also at the meeting was the charge de communication, a nice fellow clearly less senior. M. Teriiatetoofa was a very nice man and treated both of us with respect and interest. He is from one of the smaller islands (Tikehua, in the Tuamotus) population 407. On this island they have started (2 yrs ago) a program to mill coconut wood. They have six mills, (2 currently active). The locals are being trained to mill and preserve the wood by Johnny Conroy, a Tahitian who has been working with coconut wood for many (30?) years. At this point only enough wood has been produced to supply the Tikehua residents, but hey are hoping that this will be a viable industry which will be able to export wood product to the large islands. They use the 60 year old trees for the wood. This is because 1) the old trees no longer bare fruit 2) the wood is a harder making it more durable. To improve the durability they do a salt water treatment (soak it for 15 minutes so that the salt water infuses the surface, this is apparently enough to ward off fungus. Because coconut wood is very dense is does not take chemical treatments well, they just stay on the surface.) The hard wood though is difficult to cut and requires special saws and training. The interior most part of the tree is soft and not suitable for timber related uses. We are wondering what sorts of sizes the are producing as it seems like a very difficult tree to get large boards or even studs out of it. I am wondering if it may not be better suited to making sakes for roof shingles. These could be "rived" in the traditional Norwegian method for increased durability. It was unclear how much coconut is produced, they are engaging to start a uniform method of counting. There is currently excess coir material. Some is used in agriculture and they are looking into exporting some to the ils so vent (society islands) for use as a medium in the Vanilla industry, but there is clearly excess.

We showed him the FPL sample and some of our and powerpoint about coconut by-products – the coir board and the ash. He was interested in both technologies, particularly the board. They made copies of the Agrotech cut sheets and articles we brought with us and we informed them of the up coming technology transfer conference.

Benoit Layrle
Ingenieur- Charge d'etudes
Societe Environment Polynesien
(689) 54 34 53
www.sep.pf
benoit.layrl@sep.pf

- note: see supplemental summary for more in depth information

Meeting with Beniot who is in charge of a the SEP. The SEP is a non-profit organization that is funded 80% by the government. The goal of this organization is to provide recycling and modern waste disposal to French Polynesia (FP). Currently there is only 1 proper landfill in FP in Tahiti, which is a high quality landfill. Of the 180 landfills in

France only 4 are of this caliber. They conduct monitoring on a 4 month basis for the surrounding bay.

Current recycling in FP includes green and gray household bins. The green bins are located in Moorea and Tahiti for sure, and maybe in the outer islands too. The gray is for all waste, green for recyclables (plastic bottles, aluminum, paper, cardboard, etc.) Bottles are collected at specific location s(72 total) throughout the islands.

Current rates are as follows: mistakes in the green bin 11% (much lower than many industrialized countries, i.e. France 18%), 25% of recyclables are put in green bin (not good, would like to increase). Gray bin waste is sent to the landfill on Tahiti. Green waste should be composted locally, and is picked up occasionally by SEP. Green bin waste is sorted and shipped to Australia, New Zealand, China, India, Japan, Hong Kong, and Singapore. They are trying to work out a deal to have everything sent to Singapore only since they don’t generate enough of each individual recyclable (paper, aluminum, etc.) to fetch a good price. Everything would then go through a Singapore contact, but would get SEP a better price. We had heard before that sometimes the recycling was not accepted by countries, specifically NZ, but this is only if the containers have sludge, grass or other organic waste growing in them. This is due to concerns of agricultural contamination. Currently the process is a non-sum gain, and SEP is happy to get the stuff recycled without having to pay for it.

Only glass is used locally upon recycling. It is ground into aggregates ranging from 0-15mm in size. It can be used as a base in parking lots/roads, or aggregates in concrete. This was done because the technology for crushing stone could be applied to crushing glass. An attempt to create egg cartons from recycled white paper failed because the original supplier of cartons also sold chicken feed and threatened to stop selling farmers feed if they bought the recycled cartons. Local politics and economics ruined this attempt.

Otherwise, Beniot stressed that local recycling processing was not taking place because the quantities generated in FP are not big enough. Not even Hawaii does the post-processing and they are several times bigger population wise. Currently they receive 3400 tons of recycling/ year. Of which 3100 tons is actually sent to be recycled. Aluminum is 1% (very lucrative), scrap metal 6-7%, plastic bottles 12%, the rest is paper/cardboard. They currently have capacity to do 8000 tons/year.

The main point taken was that the recycling in FP is only a recent trend and much work is done to simply implement standard waste mitigation practices. Simply using a proper landfill and not dumping into a hole or rivers as is done frequently would be a great improvement. Otherwise the ability to send all the waste to be recycled, even though it is overseas is seen as an appropriate solution. In the longer run projects such as the glass recycling, and egg cartons would be appropriate. However, basic mitigation as well as limited quantities of recycling must be addressed initially.

Raimana Martin
Member of the Association Bio Fenua
(689) 42.84.84

Meeting set up by Neil Davies, who was there for most of it. RM is a Tahitian with interest in renewable energy. The Non profit org has disbanded. There was nothing really specific to be gained. He advocates micro-production of coconut oil on the islands. This could be used directly as fuel (NOT turned into biodiesel) solar energy (direct heat) could be used to make sure the oil is the proper viscosity. The oil would be used to run generators for local electricity needs on the smaller islands (any where except The society islands I guess). Also he should be contacted and Skip Staats regarding figures for waste materials from the juice factory.

Matahiarii Tutavae
Charge de Mission Environnement
MInistere due Tourismes et de l'Enviornnement
(689) 47 22 72
matahiarii.tutavae@tourisme.min.gov.pf

The afternoon meeting with M.T. was uneventful. The main focus of his office seems to be on education of younger generations about sustainability issues especially as related to island culture. He seemed to have little direct involvement at this point with any programs related to sustainable development. It is worth noting that he said they only recently heard of te MTR/OPH projects (from their visit to Gump we assume). He said they thought it sounded good and something to support, especially if it means no A/C and perhaps using waste products in construction. However there is no sense of overnment initiative. We asked if there might by an incentive program developed for manufacturers o use recycled materials in their products and the response was something like this would be a radical idea, although he didn't say radical.

Wednesday, March 28th, 2007
Rainy!!!! morning. Took ferry to Tahiti at 6:50am, and then got a ride to the SDR (Service de Developpement Rural)

Stephane Defranoux (wood expert); stephane.defranoux@rural.gov.pf
Taraina Pinson (coconut expert); taraina.pinson@rural.gov.pf
Service de developpement rural a Pirae
Rue Tuterai Tane, route de l'Hippodrome, Pirae

<u>Stephane Defranoux (wood expert):</u> Stephane gave us a good overview of the wood that is local to the island both native and introduced. There are several woods that are/ hope to be used in the artisan community (tables, crafts, etc.). In regards to construction woods the only real option was Caribbean Pine, which we had seen as the decking for the OPH. As he didn't work in the field, he didn't share the same views that the wood was very hard to work with, although he agreed that is must be pre-drilled. He does not

perhaps appreciate how much of change to regular practice this is and the difficulty it presents for builders. An demonstration house o the OPH was built using entirely C.pine. Stephane admitted hat the construction time was longer. **He will email us his data on his** His work is concerned with selecting the wood to plant, harvesting, forest management, and finally production of lumber (cutting). Actually, he must only get a contract for someone to cut the lumber. The current task is to make sure there is a contract to take in all the lumber that is ready to be harvested. After the wood is cut it can be stored, but it seems important to cut it before a certain date.

Other points of interest. 1) he said that the 'notching' (see photos) of the Caribbean Pine was normal for all lumbers- I find this hard to believe. 2) It doesn't seem that they will be introducing other construction lumber, at least in the short term.

Of particular interest was the view Stephan held about the coconut wood mills on the other island that Frederix (above) discussed. Firstly, he said there was a pilot project with one mill on the islands. However, the thought that 6 mills were in the planning was not realistic due to the limitation of the material. Furthermore, he saw the entire operation as uneconomical. To run one mill it requires 2-3 people (earning a minimum of $1650/month -- F.P. minimum wage law), 1 tractor, 1 trailer, 1 forklift, 1 preservation system (to preserve the wood, this can be chemical or salt water treated). Salt water treatment raises the concerns that you can't use it as exterior elements because the salt will leach. We want to look further into the research on this treatment. Apparently there was a training workshop in Fiji, and from that it is houht you only need to soak the wod for 15 minutes. We wonder if this treatment is effective if reapplied by brush, sponge or pressure spray.

Stephan et al are writing a book on F.P. woods past, present, indigenous and imported.

<u>Taraina Pinson (coconut expert):</u> Taraina has data on coconut production broken down by island. ** She will email us this data ** She seemed interested in our information on the coir binder-less board and has asked tat we email her the articles ** It is difficult to tell wat if any influence or work time her position could spend investigating such a project. However, she did say that finding new uses for coconut by-products was desirable. Some husk is being used in the vanilla industry and private agriculture but most is burned, presumably to get rid of it - we don't know I it may be used as fuel (cooking etc) on some islands. A "major challenge" is collecting the husks along with the copra, paying on the spot for it and then transporting husks to Tahiti for processing. We discussed the viability of manufacturing coir boards on another island. Taha is possibly the island with the largest gross copra production. We need to run numbers and compare data from Taraina with minimum source materials as defined by Agrotech. Tahaa is in the society Islands (Iles Sous le Vent), which is about as close to Moorea as you can get.
Taraina drove us to the Huilerie de Tahiti located in the shipping yard, but we could not get an appointment set. We've since been offered one tomorrow at 9am, but we will email him translated (by Pierre) questions instead, see separate document.

Mario
boucinha.m@mail.pf
Nice guy bought us lunch. He is a mold maker and artisan working with cement and lime, and concrete in specialty applications, high-end floor treatments , bathroom sink consoles etc.. Of interest to us was an island he mentioned where phosphate is mined and dead coral is tuned into cement?? We don't know if this is accurate. Raimana Martin mentioned something about the guano mining and dead coral as a possible resource from this particular island (Makatea?) so I will try to confirm this info and further investigate.

He wanted to meet to see if we had any information about his mix of cementitious material. His goal is to have a lighter material, which resists cracking, and is thin. We gave him some basic tips on water/cement ratios and such. However, these were just basic suggestions, and he has probably encountered these issues already through trial and error. However, the technical knowledge transfer was appreciated on his part.

Thursday, March 29th, 2007
It did not rain today until about 3pm. We had an unsuccessful attempt to see the workings of the juice factory. Today we drove counter clockwise past Haapiti. We found a house made mostly of bamboo. Some of the joists etc were made of imported lumber, but large posts were bamboo and the walls and ceiling were woven bamboo strips. Details, sills etc were made of coconut wood. Unfortunately all this was imported from Bali because it is cheaper than the local material. The home owners (Limoy, and daughter Natalie) said that there was a small amount of bamboo business starting here and gave us the name of someone working with it: Oliver Deane in Haapiti (check or him at the surf lodge). The house they had built 9 years earlier was still apparently in good shape. They treat it with something called "Lasure". They call the house Fare Ta Fai Fai, which means patchwork house.

Other news: We emailed thank you notes to all our contacts. Did not hear from Huilerie de Tahiti. We emailed Charles to try and set a time for Saturday. HM went snorkeling for a half hour which was totally amazing.

Friday, March 30th, 2007
Val, assistant at the Gump Station, arranged for a meeting with the Agricultural College this morning. Her husband, Monea, works there and hence we were met and given an informal tour with a member of the staff. Unfortunately this fellow spoke little English and while our French has improved it is still not ood enough to carry the conversation very far. We did gather that 1) coconut farming is no taught at the college 2) fruit and vegetables produced at the school are consumed at the school 3) Flowers are grown and sold o the hotels **4) Pig waste is used on site for fertilizing crops** 5) While a goal of the school seems to be to encourage small scale farming as a business our guide expressed that it has been his impression that the graduates are mainly not interested in pig or plant farming, they prefer to work in an office, and perhaps are young and don't accept that this may be unrealistic for some. Who knows. Our guide had only been

working there and living on Moorea for five months. Prior to this he lived on Tahiti and worked for the forestry department. He confirmed (yet again) that the utilization of Car. Pine is hampered by its hardness. Addressing this issue should be a big priority. Other news: on the lonely planet guide book map of Opunohu Valley (central Moorea) a Mape Tree Forest Reserve is sown (Mape is referred to as Tahitian Chestnut). We will inquire with Stephane Defranoux regarding this wood and its future viability as a construction material.
On our drive back we cut across the hills on a road to the bottom of Cooks bay. This took us past some of the pineapple farming.

In general I would say we have seen quite a lot of active construction here on Moorea. From OPHs, luxury villa and hotel developments and mid to upper income housing there is a lot of building going on here. This is just to say there is a market for construction materials that are durable and workable.

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